Preionization Electron Density Measurement by Collecting Electric Charge (*).

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Summary. — A method using electron collection for preionization-electron number density measurements is presented. A cathode-potential drop model is used to describe the measurement principle. There is good agreement between the model and the experimental result.

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1. – Introduction.

Preionization by X-ray or UV-radiation provides an effective method for initiating homogeneous discharges in rare-gas halide excimer laser or TEA CO₂ lasers at high gas pressures. A number of papers has been published on the study of preionization electron behaviour (1-7). The measurement of the

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preionization electron number density is required not only in the computation of the characteristics of discharge lasers, but also in the identification of preionization electron formation or loss mechanism. The measurements are often made by determining the gas mixture conductivity or electron drift current between two collecting electrodes subject to a given voltage. However, due to a very strong electromagnetic interference (typically, in the first few $\mu$s) arising from the firing of the preionizer, it is difficult to use the laser discharge electrodes as collection plates. In order to overcome this problem, we have measured preionization electron density by collecting the electric charge of the drift electrons. In this way, the measurements can be made with a high signal-to-noise ratio.

When the preionization electrons drift across the electrode gap, the positive ions are left behind near the cathode, and finally the space charge field or cathode potential drop (cathode drop) can retard the further drift of the preionization electrons. It is, therefore, necessary to know how the space charge influences the measurement results.

In this paper we use a simplified cathode potential drop model introduced in ref. (9) to illustrate the basic principle measuring preionization electron density by electric charge collection. We also present some experimental results and compare them with our analysis.

2. – Measurement principle.

Let us consider two plane electrodes with dimensions sufficiently large compared to the gap spacing $d$ between the two electrodes. The electric-field problem inside the gap can, therefore, be treated as one-dimensional. A d.c. voltage is applied across the electrode gap by a precharged capacitor $C$, which is large enough to keep the voltage $V_0$ almost unchanged during the discharge time. As we only discuss the non-self-sustaining gas discharge, with a current due only to the transfer of the initial preionization electrons generated by an ionizing pulse, the applied electric field per unit pressure $E/p$ across the gap must be so small that the Townsend avalanche in the gas processes between two electrodes may be neglected, i.e. $ad << 1$, where $a$ is the first Townsend coefficient. Generally speaking, for rare gases at pressures of $\sim 1$ atm, the aforesaid condition can be satisfied if $E/p \leq 1 \text{ V/cm} \cdot \text{Torr}$ (8). Suppose that a gas plasma

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